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Soil fertility appraisal of some selected villages in Kirmira block of Jharsuguda District under western-central table land agro-climatic zone of Odisha, India

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Abstract
A soil fertility status inventory work was carried out in some villages of Kirmira block of Jharsuguda district located in the Western Central Table Land Agro Climatic Zone of Odisha, India. Results showed that soil pH ranged between 4.3 and 6.4 and electrical conductivity of the entire study area remained below 1 dSm^{-1}. Soil Organic Carbon (SOC) content ranged between 0.17 to 0.88%. Available nitrogen content in these soils was found to be varied between 84.0 to 398.0 kg ha^{-1}. Available Bray's phosphorus content varied from 0.75 to 67.10 kg ha^{-1}. Available soil potassium content varied widely from 90 to 500 kg ha^{-1}. $CaCl_2$ extractable soil sulphur varied from 0.14 to 12.49 mg kg^{-1}. DTPA extractable micronutrients (Fe, Mn, Cu and Zn) varied from 32.62 to 192.20, 28.08 to 220.50, 0.48 to 2.86, and 0.56 2.38 mg kg^{-1} respectively. Hot water soluble boron content ranged from 0.13 to 0.88 mg kg^{-1}. All the figures in the lower range were found in upland soils while the higher values for all the parameters were found in low land soils.

Keywords: Soil fertility, agro-climatic zone, Jharsuguda district, micronutrients

1. Introduction

Kirmira block of Jharsuguda district comes under the Western Central Table Land Agro Climatic Zone of Odisha (Nanda *et al*., 2008) [20]. As per the modern system of soil classification "Soil Taxonomy" the soils of Jharsuguda district are classified under the *Alfisols, Inceptisols and Entisols* (Sahu and Mishra, 2005) [25]. Determination of soil available nutrient status of an area using the Global Positioning System (GPS) helps in formulating site-specific balanced fertilizer recommendations along with making critical decisions on nutrient management (Patil *et al*., 2017) [22]. GPS-based soil fertility evaluation not only gives ideas about the fertility status of the soil but also helps in monitoring the soil health from time to time (Mishra *et al*., 2016) [16]. Although soil fertility status and maps have been prepared for different areas of Odisha but no such intensive work had been done for the Kirmira block of Jharsuguda district. Therefore an attempt has been made in the present investigation to prepare the soil fertility status of five selected villages of Kirmira block of Jharsuguda district. As nitrogen, phosphorus and potassium are the three major primary macronutrients; sulphur is one of the most important secondary macronutrients and Fe, Mn, Cu, Zn and boron are the essential micronutrients, soil fertility status is evaluated focusing on these nutrients. Along with these parameters chemical properties are also determined which include soil pH, EC and SOC. This study will help in finding out soil fertility related crop production constraints along with suggesting remedial measures for higher crop production.

2. Materias and methods

2.1 Experimental site

Jharsuguda district is situated in the northwestern part of Odisha and is bounded between the 21° 34' North and 22°02' North latitudes and also between 83°25' East and 84°23' East longitudes. It shares its boundary with Sundargarh district in the north, Sambalpur in the east, Bargarh in the south and Chhatisgarh state in the west. Extending over a geographical area of 2081.86 sq. km, it occupies 1.41% of the area of the state. It receives 1652 mm of average annual rainfall. The district has only one sub-division (Jharsuguda) and five blocks (Jharsuguda, Lakhanpur, Kolabira, Laikera and Kirmira). It is one of the most important industrial districts of the state with a wealth of natural resources (mines and water). The most important rivers flowing through this district are Mahanadi and Ib, the water of which has been most helpful in setting up a number of industries in this district. The Mahanadi reservoir formed by Hirakud Dam is adjacent to Jharsuguda and Lakhanpur block. Jharsuguda district falls under two agroecological zones i.e.

i) West Central Table Land Zone.
ii) North Western Plateau.

Laikera block falls under North Western Plateau while the rest of the blocks come under Western Central Table Land Zone. The Minimum & maximum temperature of the district ranges from 26 to 40 °C during summer, 16.5 to 30.2 °C during winter and 25.3 to 32.5 °C during the rainy season. The district receives 1652 mm of average annual rainfall. Five villages were selected for studying the GPS-based soil fertility status namely Bhaunra (Lat. 22.009448° N, Long. 84.153026° E), Medinipur (Lat. 21.978228° N, Long. 84.124816°E), Sialrama (Lat. 21.885307° N, Long. 84.119371° E), Bijapali (Lat. 21.982104° N, Long. 84.205163° E) and Chandarpur (Lat. 21.960425° N, Long. 84.107686° E) situated in Kirmira block of Jharsuguda district.

2.2 Soil Sampling and analysis

The landform of the study area was determined by traversing the area and elevations above MSL of different points were recorded using a GPS instrument (Garmin make; model: 76MAPCSx). Total 60 numbers of composite surface (0-15 cm) soil samples were collected from the study area which includes 12 samples from each village from different land types such as upland, medium land and low land. Composite soil samples were collected along with the latitude and longitude of the plots with the help of a GPS instrument. Soils were analyzed for their pH (1:2) (Jackson, 1973) [10], EC (1:2) (Jackson, 1973) [10], organic carbon (Walkley and Black, 1934) [28] as described by Page *et al*., (1982) [21], available nitrogen (Subbiah and Asija, 1956) [26], phosphorus (Bray and Kurtz, 1945) [5], potassium (Hanway and Heidel, 1952) [9] and sulphur (Chesnin and Yien, 1950) [6]. The micronutrients such as Fe, Mn, Cu and Zn were estimated using DTPA solution (Lindsay and Norvell, 1978) [13] and hot water extractable boron (John *et al*., 1975) [11].

3. Results and Discussion

3.1 Soil reaction

Soil pH (1:2) of surface soil samples of Bhaunra village were found to be varied in between 5.3 to 5.9 i.e. highly acidic to moderately acidic with a mean value of 5.57; that of soils of Mednipur village varied between 5.5 to 6.4 i.e. highly acidic to moderately acidic with a mean value of 5.14; that of Sialrama varied between 4.8 to 5.7 i.e. very strongly acidic to moderately acidic with a mean value of 5.24; that of soils of Bijapali village varied between 5.1 to 5.7 i.e. highly acidic to moderately acidic with a mean value of 5.38; that of soils of Chandarpur village varied between 4.3 to 4.9 i.e. extremely acidic to highly acidic with a mean value of 4.52 (Table 1). Soil pH is significantly and positively correlated with OC (r=0.67**) and N (r=0.59*), positively and non-significantly correlated with K (r=0.) and B (r=0.03) but negatively and non-significantly correlated with P (r= -27) and S (r= -25. Similar findings have been observed by Mishra (2005). The data showed a gradual increase in soil pH value from the upland towards low land, which could be attributed to the removal of basic cations with runoff water from upland and medium land during intensive rainfall and their subsequent deposition in the low land. Hence, soil acidity appears to be a major crop production constraint in the study area. Similar findings have also been reported earlier by Priyadarshini *et al*., (2017) [24], Dash *et al*., (2018) [7] Swain *et al*., (2019) [27] and Mohapatra *et al*., (2020) [18].

3.2 Electrical conductivity

The Electrical Conductivity (1:2) of surface soil samples of the entire study area was found to be less than 1dS m^{-1} (Table 1). Hence, all the soils under the study area are safe for all types of crop production with respect to the soluble salt content.

3.3 Organic carbon

Soil Organic Carbon (SOC) of surface soil samples of Bhaunra village were found to be varied in between 0.26 to 0.88% i.e. low to high content with a mean value of 0.58%; that of soils of Mednipur village varied between 0.24 to 0.76% i.e. belong to very low to high organic carbon content with a mean value of 0.49%; that of Sialrama varied between 0.36 to 0.63% i.e. low to medium content with a mean value of 0.46%; that of soils of Bijapali village varied between 0.56 to 0.77% i.e. moderate to high with a mean value of 0.65%; that of soils of Chandarpur village varied between 0.17 to 0.43% i.e. ranged from very low to low soil organic carbon content with a mean value of 0.29%. The results clearly showed a gradual increase in SOC from upland towards low land surface soil samples which could be attributed to higher cropping intensity aided with more crop residue incorporation in the same. Again, due to the higher water table, the oxidation of organic matter is slower in low-land areas than that in upland areas. In the entire study area, organic carbon status was found to be very low to high range which enables the soil for growing a wide range of crops. Soil organic carbon is significantly and positively correlated with N (r=0.99**), K (r=0.73**), Fe (r=0.57*) and Mn (r=0.78**) (Table 4). Similar findings have also been reported by Mishra (2013) [14], Digal *et al*., (2018) [8], Swain *et al*., (2019) [27] and Mohapatra *et al*., (2020) [18].

3.4 Available nitrogen

Available soil nitrogen content of surface soil samples of Bhaunra village were found to vary between 116 to 398 kg ha^{-1} with a mean value of 253.66 kg ha^{-1}; that of soils of Mednipur village varied between 115 to 332 kg ha^{-1} with a mean value of 216 kg ha^{-1}; that of soils of Sialrama varied between 143 to 283 kg ha^{-1} with a mean value of 218.66 kg ha^{-1}; that of soils of Bijapali varied between 266 to 367 kg ha^{-1} with a mean value of 311.33 kg ha^{-1}; that of soils of Chandarpur village varied between 84 to 209. kg ha^{-1} with a mean value of 143 kg ha^{-1} (Table 2). The results clearly showed a gradual increase in average N content from upland to low land which could be attributed to the increased SOC in the low land than that of upland and medium land as N is released from the soil organic matter by the activity of micro-organisms). Available N was found to be positively and significantly correlated with organic carbon (r=0.99**), K (r=0.68**), Fe (r=0.63*), Mn (r=0.76**) but negatively and non-significantly correlated with B (r= -0.04) (Table 4). In the entire study area, the available soil nitrogen content varied between low to medium. Similar findings were reported by Behera *et al*., (2016) [4] and Swain *et al*., (2019) [27].

Table 1: Chemical Properties of Soil of the Study Area

Name of Village	Land Type	pH		EC (dS m^{-1})		OC (%)	
		Range	Mean	Range	Mean	Range	Mean
Bhaunra	Upland	5.3-5.5	5.37	0.05-0.10	0.07	0.26-0.43	0.34
	Medium Land	5.5-5.6	5.52	0.08-0.10	0.08	0.57-0.63	0.60
	Low Land	5.7-5.9	5.82	0.09-0.12	0.10	0.76-0.88	0.82
Medinipur	Upland	5.5-5.8	5.65	0.09-0.13	0.10	0.24-0.43	0.36
	Medium Land	5.9-6.1	5.97	0.10-0.20	0.14	0.34-0.56	0.44
	Low Land	6.1-6.4	6.25	0.11-0.20	0.16	0.63-0.76	0.67
Sialrama	Upland	4.8-5.1	4.95	0.06-0.10	0.08	0.36-0.44	0.40
	Medium Land	5.1-5.4	5.22	0.09-0.12	0.10	0.43-0.50	0.47
	Low Land	5.4-5.7	5.55	0.14-0.24	0.19	0.48-0.63	0.54
Bijapali	Upland	5.1-5.2	5.12	0.13-0.20	0.16	0.56-0.63	0.58
	Medium Land	5.3-5.5	5.42	0.18-0.24	0.21	00.63-0.69	0.65
	Low Land	5.6-5.7	5.62	0.16-0.23	0.18	0.69-0.77	0.72
Chandarpur	Upland	4.3-4.6	4.47	0.19-0.22	0.21	0.17-0.26	0.22
	Medium Land	4.6-4.7	4.62	0.15-0.23	0.18	0.26-0.34	0.30
	Low Land	4.7-4.9	4.47	0.18-0.26	0.22	0.26-0.43	0.36

Table 2: Available Nutrient Status of Soil of the Study Area

Name of Village	Land Type	N		P		K		S	
		(kg ha^{-1})						(mg ha^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Bhaunra	Upland	116-146	128	0.75-0.98	0.87	320-370	345	4.32-4.85	4.56
	Medium Land	246-284	262	1.22-1.72	1.46	420-470	445	5.12-5.82	5.57
	Low Land	349-398	371	2.21-2.49	2.37	470-500	485	5.82-8.32	7.26
Medinipur	Upland	115-196	163	3.47-4.66	3.95	90-130	110	0.14-0.34	0.21
	Medium Land	168-244	193	4.66-5.63	5.05	210-220	212.5	0.34-0.54	0.41
	Low Land	276-322	292	5.63-6.37	5.99	250-270	260	0.58-0.96	0.69
Sialrama	Upland	143-198	175	22.6-26.95	24.70	120-130	127.5	0.19-0.39	0.32
	Medium Land	189-246	219	27.59-34.78	31.20	130-150	140	0.43-0.58	0.53
	Low Land	237-283	262	34.78-39.69	37.28	150-160	155	0.67-1.59	0.97
Bijapali	Upland	266-293	276	23.76-25.91	24.28	260-300	275	5.21-7.36	1.82
	Medium Land	293-334	312	28.17-39.69	34.63	330-360	340	7.36-8.32	7.98
	Low Land	334-367	346	50.71-67.10	59.26	370-420	395	10.06-12.49	11.27
Chandarpur	Upland	84-127	107	14.70-19.84	17.45	130-150	140	4.56-4.85	4.70
	Medium Land	127-169	146	20.33-23.76	21.97	160-180	172.5	5.12-5.21	5.16
	Low Land	127-209	176	25.91-28.17	27.14	180-220	197.5	7.63-12.49	9.62

Table 3: Available Micronutrient Status of Soil of the Study Area

Name of Village	Land Type	Fe		Mn		Cu		Zn		B	
		(mg kg^{-1})									
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Bhaunra	Upland	45.78-62.18	56.42	71.96-108.16	88.23	0.72-0.84	0.79	0.56-0.70	0.65	0.13-0.18	0.15
	Medium Land	65.82-78.46	71.90	108.42-147.76	134.20	0.84-1.40	1.25	0.72-1.24	1.06	0.18-0.24	0.21
	Low Land	82.22-97.56	90.68	157.76-220.50	199.40	1.42-1.84	1.63	1.36-2.38	1.87	0.24-0.44	0.39
Medinipur	Upland	46.38-63.22	55.59	58.74-78.46	68.52	0.66-1.08	0.93	0.88-1.24	1.08	0.24-0.56	0.35
	Medium Land	68.32-88.24	78.08	81.22-132.66	98.53	1.20-1.44	1.30	1.36-1.48	1.40	0.56-0.69	0.62
	Low Land	98.02-99.32	98.48	138.02-195.32	165.92	1.46-1.98	1.75	1.62-1.98	1.75	0.72-0.84	0.77
Sialrama	Upland	32.62-36.24	34.05	28.09-45.32	37.31	0.86-1.34	1.10	0.84-1.24	1.06	0.31-0.56	0.46
	Medium Land	42.36-51.34	46.35	46.88-69.84	60.62	1.34-1.42	1.39	1.36-1.42	1.37	0.56-0.66	0.61
	Low Land	61.42-71.68	66.16	78.46-98.20	86.51	1.48-1.96	1.69	1.48-1.98	1.68	0.69-0.78	0.73
Bijapali	Upland	74.86-92.84	82.65	71.96-94.56	83.25	0.72-0.84	0.79	0.68-0.86	0.76	0.13-0.18	0.14
	Medium Land	97.56-164.40	133.79	108.16-137.60	122.94	0.85-1.42	1.26	1.22-1.42	1.34	0.18-0.22	0.21
	Low Land	166.4-192.20	180.55	137.60-220.50	192.09	1.42-1.86	1.64	1.43-1.82	1.63	0.24-0.44	0.39
Chandarpur	Upland	45.38-64.78	59.00	74.88-87.34	78.56	0.48-0.96	0.76	0.68-1.06	0.82	0.24-0.31	0.27
	Medium Land	65.35-80.90	72.07	91.62-99.34	97.29	0.98-2.32	1.60	1.64-1.82	1.74	0.31-0.72	0.60
	Low Land	83.12-140.04	110.93	99.52-106.20	101.31	2.54-2.86	2.66	1.86-2.38	2.09	0.84-0.88	0.85

Table 4: Correlation between Different Soil Properties of the Study Area

	pH	EC	OC	Av N	Av P	Av K	Av S	Av Fe	Av Mn	Av Cu	Av Zn	Av B
pH	1											
EC	-0.34	1										
OC	0.67**	-0.06	1									
Av N	0.59*	0.07	0.99**	1								
Av P	-0.27	0.55*	0.16	0.29	1							
Av K	0.41	-0.19	0.73**	0.68**	-0.12	1						

Av S	-0.25	0.4	0.27	0.32	0.38	0.59*	1					
Av Fe	0.21	0.54*	0.57*	0.63*	0.54*	0.53*	0.75**	1				
Av Mn	0.51*	0.14	0.78**	0.76**	0.04	0.8**	0.6*	0.74**	1			
Av Cu	-0.04	0.42	0.23	0.27	0.29	0.06	0.42	0.44	0.38	1		
Av Zn	0.12	0.41	0.35	0.4	0.27	0.07	0.34	0.45	0.5	0.93**	1	
Av B	0.03	0.32	-0.07	-0.04	0.16	-0.44	-0.16	0.02	0.01	0.79**	0.78**	1

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

3.5 Available phosphorus

Available soil phosphorus content of surface soil samples of Bhaunra village was found to be varied between 0.75 to 2.49 kg ha^{-1} with a mean value of 1.56 kg ha^{-1}; that of soils of Medinipur village varied between 3.47 to 6.37 kg ha^{-1} with a mean value of 4.99 kg ha^{-1}; that of soils of Sialrama village varied between 22.6 to 39.69 kg ha^{-1} with a mean value of17 kg ha^{-1} ; that of soils of Bijapali village varied between 23.76 to 67.10 kg ha^{-1} with a mean value of 39.09 kg ha^{-1}; and that of soils of Chandarpur village varied between 14.70 to28.17 kg ha^{-1} with a mean value of 22.18 kg ha^{-1} (Table 2). The results clearly showed a gradual increase in average P content from upland to low land which could be attributed to the increased SOC in the low land than that of upland and medium land (as organic fractions of available phosphorus are mobilized to plant available form by the activity of micro-organisms). Available P was found to be positively correlated with organic carbon (r=0.16) and B (r=0.16). In the entire study area, available phosphorus was found be within the range of low to high. Similar trends of available P were also observed by Barik *et al*. (2017) [3] and Swain *et al*., (2019) [27].

3.6 Available potassium

The available soil potassium content of surface soil samples of Bhaunra village were found to be varied between 320 to 500 kg ha^{-1} with a mean value of 425kg ha^{-1}; that of soils of Medinipur village varied between 90 to 270 kg ha^{-1} with a mean value of 194.16 kg ha^{-1}; that of soils of Sialrama varied between 120 to 160 kg ha^{-1} with a mean value of 140.83 kg ha^{-1}; that of soils of Bijapali varied between 260 to 420 kg ha^{-1} with a mean value of 336.66 kg ha^{-1}; that of soils of Chandarpur village varied between 130 to 220 kg ha^{-1} with a mean value of 170 kg ha^{-1} (Table 2). The results clearly showed a gradual increase in average K content from upland to low land which could be attributed to the increased clay content in the low land than that of upland and medium land (potassium ion being a cation present in the exchange site of negatively charged clay particles). The available potassium found to be positively and significantly correlated with organic carbon (r=0.73**), N (r=0.68**), S (r=0.59*), Fe (r= 53*), Mn (r=0.80**) but negatively correlated with B (r= -0.44). In the entire study area available potassium was found within the range of low to high. Similar results were also observed by Mishra *et al*. (2017) [15] and Dash *et al*. (2018) [7].

3.7 Available Sulphur

Available soil sulphur content of Bhaunra village were found to vary between 3.32 to 8.32 mg kg^{-1} with a mean value of 5.79 mg kg^{-1}; that of soils of Medinipur village varied between 0.14 to 0.96 mg kg^{-1} with a mean value of 0.43 mg kg^{-1}; that of soils of Sialrama varied between 0.19 to 1.59 mg kg^{-1} with a mean value of 0.60 mg kg^{-1}; that of soils of Bijapali varied between 5.21 to 12.49 mg kg^{-1} with a mean value of 7.02 mg kg^{-1}; that of soils of Chandarpur village varied between 4.56 to 12.49 mg kg^{-1} with a mean value of 6.49 mg kg^{-1} (Table 2). The results clearly showed a gradual increase in average S content from upland to low land which could be attributed to the increased SOC content in the low land than that of upland and medium land (as S is released from the soil organic matter by the activity of micro-organisms). Available S was found to be positively correlated with organic carbon (r=0.27), N (r=0.32), P (r=0.38) and positively and significantly correlated with and K (r=0.59*), Fe (r=75**) and Mn (r=0.60*) (Table 4). In the entire study area, the available sulphur was found to be in the range of low to medium. Similar results were also reported by Nahak *et al*. (2016) [19] and Mishra (2016) [16].

3.8 Available Micronutrients

3.8.1 DTPA Extractable (Fe, Mn, Cu & Zn)

DTPA extractable micronutrients content of Bhaunra village were recorded with Fe (ranging from 45.78 to 97.56 mg kg^{-1} with an average of 73 mg kg^{-1}), Mn (ranging from 71.96 to 220.50 mg kg^{-1} with an average of 140.61 mg kg^{-1}), Cu (ranging from 0.72 to 1.84 mg kg^{-1} with an average of 1.22 mg kg^{-1}), Zn (ranging from 0.56 to 2.38 mg kg^{-1} with an average 1.19 mg kg^{-1}); that of soils of Medinipur village were recorded with Fe (ranging from 46.38 to 99.32 mg kg^{-1} with an average of 77.38 mg kg^{-1}), Mn (ranging from 58.74 to 195.32 mg kg^{-1} with an average of 110.99 mg kg^{-1}), Cu (ranging from 0.66 to 1.98 mg kg^{-1} with an average of 1.32 mg kg^{-1}), Zn (ranging from 0.88 to 1.98 mg kg^{-1} with an average of 1.41mg kg^{-1}), that of soils of Sialrama village were recorded with Fe (ranging from 32.62 to 71.68 with an average of 48.85 mg kg^{-1}), Mn (ranging from 28.08 to 98.20 mg kg^{-1} with an average of 61.48 mg kg^{-1}), Cu (ranging from 0.86 to 1.96 mg kg^{-1} with an average of 1.39 mg kg^{-1}), Zn (ranging from 0.84 to 1.98 mg kg^{-1} with an average of 1.37 mg kg^{-1}); that of soils of Bijapali village were recorded with Fe (ranging from 74.86 to 192.20 with an average of 132.33 mg kg^{-1}), Mn (ranging from 71.96 to 220.50 mg kg^{-1} with an average of 132.76 mg kg^{-1}), Cu (ranging from 0.72 to 1.86 mg kg^{-1} with an average of 1.23 mg kg^{-1}) Zn (ranging from 0.68 to 1.82 mg kg^{-1} with an average of 1.24 mg kg^{-1}); that of soils of Chandarpur village were recorded with Fe (ranging from 45.38 to 140.04 mg kg^{-1} with an average of 80.66 mg kg^{-1}), Mn (ranging from 74.88 to 106.20 mg kg^{-1} with an average of 92.38 mg kg^{-1}), Cu (ranging from 0.48 to 2.86 mg kg^{-1}with an average of 1.67 mg kg^{-1}), Zn (ranging from 0.68 to 2.38 mg kg^{-1} with an average 1.55 mg kg^{-1}) (Table 3). Considering 0.6 mg kg^{-1} as the critical limit of available Zn as suggested by (Lindsay and Norvell, 1978), except an upland sample of Bhaunra, soils of all the villages were found to be sufficient in zinc status. Considering 4.5, 2.0 and 0.2 mg kg^{-1} are the critical limits of Fe, Mn and Cu respectively, all the soil samples were found to be sufficient in Fe, Mn and Cu. Similar findings were also reported by Athokpam *et al*., (2016) [2], Khanday *et al*., (2017) [12], Athokpam *et al*., (2018) [1] and Mohanta *et al*., (2020) [17].

3.8.2 Available boron

Hot water extractable boron content of the surface soil samples of Bhaunra village were found to vary between 0.13 to 0.44 mg kg^{-1} with a mean value of 0.25 mg kg^{-1}; that of

Medinipur village varied between 0.24 to 0.84 mg kg^{-1} with a mean value of 0.58 mg kg^{-1}; that of Sialrama varied between 0.31 to 0.78 mg kg^{-1} with a mean value of 0.60 mg kg^{-1}; that of Bijapali village varied between 0.13 to 0.44 mg kg^{-1} with a mean value of 0.24 mg kg^{-1}; that of Sialrama village varied between 0.24 to 0.88 mg kg^{-1} with a mean value of 0.57 mg kg^{-1} (Table 3). The results clearly showed a gradual land which could be attributed to the increased SOC content in the low land than that of upland and medium land. This type of result is in close conformity with results obtained by Pattanayak (2016) [23] and Swain *et al*., (2019) [27].

4. Summary

From the above study it was observed that (10%) of the total soil samples were investigated to be strongly acidic followed by (90%) of moderately acidic. With regard to organic Carbon content, predominantly low organic carbon was recorded in (52%) of the area followed by a medium range of (36%). Only (12%) of soil samples were detected to be sufficient in organic carbon content. (42%) of the soil samples were reported as low in available nitrogen content and the remaining (58%) of samples were found to be of a medium range. The available phosphorus of the samples were chiefly recorded as of medium range (53%) followed by a low range of (40%) and only (7%) of the samples were detected to be sufficient in available phosphorous. Available potassium was found to be predominantly low (50%), medium (20%) and in high range (30%). While 87 percent of the soil samples were investigated to be in low range of available sulphur and only (13%) of the samples were found to be in the medium range. The DTPA extractable iron and manganese content of the entire study area were found to be very high up to 192.20 mg kg^{-1} and 220.50 mg kg^{-1} respectively against the critical level 4 mg kg^{-1} for iron and 1.0 mg kg^{-1} for manganese [Table 4]. The high values of Fe and Mn may be explained as the soils of the area under study have been formed from river alluvium and are classified as *Typic Haplaquepts* and *Aeric Haplaquents* consisting of the sediments which originated from the weathered product of a rock system belonging mainly to the iron ore series containing *garnetiferous gneiss*, schist and rocks of Singhbhum granites. A similar observation has also been reported earlier by Nahak *et al*., (2016) [19]. The mean DTPA extractable zinc content was above the critical limit (0.6 mg kg^{-1}) and the copper content of the entire study area was investigated to be high up to 2.86 mg kg^{-1}, considering the critical limit (0.2 mg kg^{-1}) [Table 4]. However, the hot water soluble boron content was detected to have remained below the critical limit (<0.5 mg kg-1) [Table 4] which covered (24%), medium range (50%) and high range (26%) of the total investigation area.

5. Conclusion

It can be concluded that this study on GPS-based soil sample collected from some villages of Kirmira block of Jharsuguda district of Odisha, could help to determine the nutrient status of specific sites and thus helps in site-specific nutrient management by balanced recommendation of fertilizer for various crops. Site-specific nutrient management not only reduces environmental pollution due to excessive fertilizers but also cut short the expenditure of farmers. By collecting and analyzing the geo-referenced soil samples at intervals, the change in soil fertility status can be monitored and remedial measures can also be suggested to maintain soil health for sustainable crop production.

6. Reference

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